IPART
New South Wales

Independent Pricing and Regulatory Tribunal

FACT SHEET

Home battery systems

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Some retailers are offering battery storage systems that allow you to use your PV electricity at night instead of drawing electricity from the grid. We have used a case study to analyse the financial implications of installing one of these systems. We found that the financial implications vary depending on factors such as the size of the customer's PV unit and battery, the customer's daily electricity usage amount and pattern, and the electricity tariffs they are on.

However, based on our research of current battery prices, it would likely take more than 10 years for an existing solar customer to recover the initial costs of the battery storage system.[1] As was the case with PV units, the cost of battery storage is likely to fall substantially in the future.

Our analysis is based on a number of assumptions and should not be considered financial advice. As a solar customer you should undertake your own research before making a decision on buying a battery storage system.

1 Combining a home battery with your PV unit

Home battery storage can add reliability and versatility to your solar system. It can potentially help lower your electricity bill in three ways:

- It stores excess PV electricity generated during the day to be used in the evening and at times when the PV unit does not produce electricity due to insufficient sunlight.
- If you are on a time-of-use tariff you can take advantage of lower off-peak electricity tariffs by charging up the battery during the off-peak hours and using the stored electricity during peak hours when tariffs are higher.
- It prioritises using the stored electricity in the batteries over importing electricity from the grid, maximising the value of their solar system by using as much on-site generation as possible.

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[1] See our case studies in Appendix A.

2 Battery prices are still relatively expensive

While using home battery storage can provide financial benefits, you need to weigh up these benefits against the cost of investing in the system in the first place.

We used a case study to analyse the benefits and costs of installing a home battery system for customers with different sized PV units. We found that, at current retail battery prices, the cost per kilowatt hour (kWh) of electricity stored may be more than buying this electricity direct from the grid. In the sample of systems we looked at, the current cost, including installation and an inverter, ranged from $0.72 to $1.53 per kWh over the expected battery life.[2] This means that the unit cost of storing and using excess solar generation may be higher than buying electricity direct from the grid at around 27 cents to 42 cents per kWh on average.[3]

We also found that it would likely take more than 10 years for an existing solar customer to recover the initial costs of the battery storage system.[4] This is longer than the warranty period for most systems in the market.

These findings suggest that if the main reasons you want a battery storage system are financial, you may want to wait a while. As was the case with PV units, the cost of battery storage is likely to fall substantially in the future.[5]

Appendix A provides more information on our case study analysis. Appendix B provides details on a range of home battery storage systems currently on the market.

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[2] This benchmark compares the relative cost effectiveness of battery systems. It is calculated by dividing the retail price of the battery with 'Warranted kWh (1 cycle per day)' over the expected asset life of a battery system. See Table B.1 in Appendix B.

[3] Section A.2 explains how we have estimated the range for the cost of electricity for a customer on a time-of-use tariff in our case study.

[4] See our case studies in Appendix A.

[5] https://onestepoffthegrid.com.au/tesla-effect-means-australian-battery-storage-prices/ accessed 21 November 2016.

Box 2.1 Further information

We have published a series of information papers to help SBS customers make informed decisions about the tariff and technology options available to them, including more detailed papers on:

- why SBS customers should get a net meter
- why SBS customers should shop around for the best electricity offer
- why unsubsidised feed-in tariffs are less than the retail price of electricity, and
- home battery storage systems.

You will find these papers on our website (www.ipart.nsw.gov.au).

We have also developed an Excel tool to help you compare different offers in terms of their feed-in tariffs and retail prices. You can also find this tool on our website (www.ipart.nsw.gov.au)

A Case study: Economics of adopting battery storage

To evaluate whether purchasing a battery storage system is an investment option for you, we have analysed the:

- simple payback period (the length of time required for an investment to recover its initial cost)
- discounted payback period (the length of time required for an investment to recover its initial cost, taking into account the time value of money – that is, that a dollar today is worth more than a dollar in the future), and
- net present value (NPV) of the investment.

We calculated the NPV of purchasing a battery storage system as:

- the total savings on the electricity bill by using the stored PV electricity at night, less
- the initial cost of the battery storage.

Based on current mortgage rates, we have used an interest rate of 2% in real terms to calculate the NPV. A positive (negative) NPV indicates a solar customer would make a net profit (loss) after taking into account the initial upfront cost of their battery storage.

A.1 Assumptions

We have analysed the economics of adopting battery storage for two solar customers, **Customer 1** and **Customer 2**. Table A.1 sets out our assumptions.

Table A.1 Assumptions for the case study

	Customer 1	Customer 2
PV unit details		
PV unit size	3.0 kW	5.0 kW
Daily PV generation	10.2 kWh	15.6 kWh
Metering arrangement	Net	Net
Electricity consumption		
Daily electricity consumption	17.8 kWh	26.0 kWh
% of consumption during the day time when a PV unit produces electricity	46%	46%
Battery storage details		
System size	7.0 kWh	10.0 kWh
System working capacity	6.4 kWh	9.2 kWh
Costs on 1 January 2017 (ex-GST)	$10,909	$13,636
Costs on 1 January 2019 (ex-GST)[a]	$6,545	$8,182
Common assumptions to Customer 1 and Customer 2		

Electricity tariffs (ex-GST)	
Peak, 2pm and 8pm (cents per kWh)	49.24
Shoulder, 7am to 2pm and 8pm to 10pm (cents per kWh)	19.26
Off-peak, 10pm and 7am (cents per kWh)	10.83
Daily supply charge (cents per day)	85.76
Feed-in tariffs (cents per kWh)	6.5
Discount rate (real terms)	2%

a: We assume that the battery costs decrease by 40% from 1 January 2017 to 1 January 2019.

Note: Costs and electricity tariffs are ex-GST. Our discount rate of 2% is based on a current mortgage rate of 4.5% and an inflation rate of 2.5%.

The cost of a battery storage system may fall in the future, largely driven by an increase in scale in global manufacturing and the local industry.[6] We have analysed the financial outcomes where the costs of an installed 7 kWh and 10 kWh battery storage system fall by 40% from 1 January 2017 to 1 January 2019. For simplicity, we assume that all other assumptions in Table A.1 remain unchanged over time.

Our analysis focuses on the financial impact of purchasing a battery storage system on a customer with an **existing** PV unit. Hence we compare benefits and costs **with** and **without** a battery storage system. We do not consider benefits and costs associated with a PV unit, as these would be incurred irrespective of whether the customer purchased a battery storage system. Specifically, our analysis presented below does not take into account:

- costs of a PV unit
- feed-in tariffs, and
- savings on the electricity bill by avoiding electricity import from the grid during the day time.

A.2 Scenarios

We analysed the NPV, payback period and discounted payback period for two scenarios.

A.2.1 Scenario 1

In Scenario 1**, Customer 1** and **Customer 2** install a 7 kWh and 10 kWh battery storage system, respectively. In this scenario, the customers' PV electricity is first stored in the battery with any excess PV electricity being exported to the grid.

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[6] http://reneweconomy.com.au/australian-battery-storage-costs-may-fall-40-two-years-28839/ accessed 7 November 2016.

- **Customer 1** is assumed to have a 3 kW PV unit which is expected to generate around 10.2 kWh per day, on average. A 7 kWh battery system can store around 6.4 kWh per day given typical battery efficiency (92%).[7] The stored PV electricity (6.4 kWh) would be used to offset the equivalent amount of the customer's energy use. The remaining PV electricity (3.2 kWh) is assumed to be exported to the grid.
- **Customer 2** is assumed to have a 5 kW PV unit which is expected to generate around 15.6 kWh per day, on average. A 10 kWh battery system can store around 9.2 kWh per day per day given typical battery efficiency (92%). The stored PV electricity (9.2 kWh) would be used to offset the equivalent amount of the customer's energy use. The remaining PV electricity (5.6 kWh) is assumed to be exported to the grid.

A.2.2 Scenario 2

In Scenario 2, **Customer 1** and **Customer 2** install a 7 kWh and 10 kWh battery storage system, respectively. In this scenario, the customers' PV electricity is first used by the home during the day when PV electricity is being generated. Any excess PV electricity is stored in the battery. If there is any further PV electricity remaining, it is exported to the grid.

- **Customer 1** is assumed to have a 3 kW PV unit which is expected to generate around 10.2 kWh per day, on average. 8.2 kWh of this would be used to meet the customer' electricity demand during the time the PV unit produces electricity. This means the customer would avoid importing 8.2 kWh of electricity from the grid during this time. Of the remaining 2 kWh, 1.8 kWh would be stored in the battery given typical battery efficiency (92%). The stored electricity of 1.8 kWh would be used to offset the equivalent amount of the customer's energy use. For **Customer 1** there is no PV electricity remaining that can be exported to the grid.
- **Customer 2** is assumed to have a 5 kW PV unit which is expected to generate around 15.6 kWh per day, on average. 12 kWh of this would be used to meet the customer's electricity demand during the time the PV unit produces electricity. Of the remaining 3.6 kWh 3.3 kWh would be stored in the battery, given the battery efficiency (ie, 92%). The stored electricity would be used to offset the equivalent amount of the customer's energy use. For **Customer 2** there is no PV electricity remaining that can be exported to the grid.

As shown in Table A.1, **Customer 1** and **Customer 2** are on a time-of-use (TOU) tariff.[8] TOU pricing typically divides electricity tariffs between Peak (2pm–8pm weekdays), Shoulder (7am–2pm and 8pm–10pm on weekends) and Off Peak (all other times) with Off Peak being the least expensive. We have analysed the NPV, payback period and discounted payback period for both **Customer 1** and

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[7] https://www.choice.com.au/home-improvement/energy-saving/solar/articles/tesla-powerwall-payback-time accessed 30 November 2016.

[8] To be on a TOU tariff, you must have an interval or smart meter.

Customer 2 when they consume 25%, 50%, and 75% of the stored electricity during the 2pm to 8pm Peak period.

Based on the TOU tariffs presented in Table A.1, if **Customer 1** and **Customer 2** consume 25% of the PV electricity stored in their battery system during the Peak period and the remainder during the Shoulder period, they would save on average 26.76 cents per kWh. If the consumption of the stored PV electricity during the Peak period increases to 75%, the saving would increase to 41.75 cents per kWh. The benefits of having a battery storage estimated in our case studies range from 26.76 to 41.75 cents per kWh on average.

We consider that using a range between 25% to 75% of stored electricity in the Peak period is reasonable. Customers on a TOU tariff would likely attempt to shift their consumption of stored PV electricity to the Peak period when the price of electricity is most expensive. However, they would not be able to use 100% of their stored electricity in the Peak period because typically the Peak rate does not apply on weekends and public holidays. For this reason, we have estimated the maximum benefit per kWh based on the assumption of using 75% of the stored electricity during the Peak period.

The financial analysis discussed here relies on several assumptions. The economics of purchasing battery storage will be different depending on a customer's individual circumstances such as the size of their PV unit and battery storage they intend to purchase, the customer's daily consumption amount and pattern, electricity tariffs they are on, etc. Therefore, our analysis presented here is specific to the assumptions used, and should not be considered financial advice. Customers should undertake your own research before making a decision on buying a battery storage system.

A.3 Results

A.3.1 Scenario 1

In Scenario 1, we assume that **Customer 1** and **Customer 2**'s PV electricity is first stored in the battery, and any excess PV electricity is exported to the grid, earning an unsubsidised feed-in tariff of 6.5 cents per kWh.

Table A.2 Results for Scenario 1

Peak period consumption of the stored PV electricity (%)	Savings per kWh (cents per kWh)	Total savings ($ per annum)	Payback period (years)	Discounted payback period (years)	NPV ($)
Customer 1 - purchased 7 kWh battery on 1 January 2017					
25%	26.76	629	17	21	-5,245
50%	34.25	805	14	16	-3,659
75%	41.75	981	11	13	-2,072
Customer 1 - purchased 7 kWh battery on 1 January 2019					
25%	26.76	629	10	12	-882
50%	34.25	805	8	9	705
75%	41.75	981	7	7	2,291
Customer 2 – purchased 10 kWh battery on 1 January 2017					
25%	26.76	898	15	18	-5,545
50%	34.25	1,150	12	14	-3,279
75%	41.75	1,402	10	11	-1,012
Customer 2 – purchased 10 kWh battery on 1 January 2019					
25%	26.76	898	9	10	-91
50%	34.25	1,150	7	8	2,176
75%	41.75	1,402	6	6	4,442

Note: The 10-year NPVs are calculated as of the date when the battery is purchased. The remaining stored PV electricity is assumed to be used in the Shoulder period.

Source: IPART analysis.

The results show that, for example, if **Customer 1** purchased a 7 kWh battery on 1 January 2017 and consumed 50% of the stored PV electricity during the Peak period, then they would save on average 34.25 cents per kWh on their electricity bill or $805 per annum. The simple payback time would be around 14 years, meaning it would take over 14 years to recover the initial cost of the battery storage system. Taking into account the time value of money, the payback time would be 16 years. These payback periods are longer than the most warranty period of 10 years for the battery storage systems in the market. The 10-year NPV as at 1 January 2017 is -$3,659. A negative NPV indicates that the cost of having a battery storage system is greater than the benefits that could be accrued over the next 10 years in today's dollars.

The results for Scenario 1 show that:

- With a TOU tariff, the financial benefits improve and the payback periods decrease as more of the stored PV electricity is consumed during the Peak period when the price of electricity is the highest.
- For a battery purchased on 1 January 2017, in all cases there is a negative NPV over a 10 year period, and the payback and discounted payback periods are longer than or equal to 10 years.

- The economics of purchasing a battery system are likely to improve when the costs of a battery system reduce. For example, if **Customer 1** purchased the same battery system two years later (ie, on 1 January 2019) at a lower cost (see Table A.1), the payback and discounted payback periods would decrease materially, and the NPV would improve substantially and may be positive.
- While the savings per kWh for **Customer 2** are the same as for **Customer 1,** the total savings **Customer 2** receives are greater due to the bigger battery capacity. However, this may be offset by a relatively higher battery cost compared to Customer 1 (particularly for batteries purchased on 1 January 2017).

A.3.2 Scenario 2

In Scenario 2, we assume that the customers' PV electricity is first used to meet their demand during the day when PV electricity is being generated. Any excess PV electricity is then stored in the battery storage system. If there is still any PV electricity remaining, it is exported to the grid, earning an unsubsidised feed-in tariff of 6.5 cents per kWh.

Similar to Scenario 1, key findings from Scenario 2 (shown in Table A.3) are:

- With a TOU tariff, the financial benefits improve and the payback periods decrease as more of the stored PV electricity is consumed during the Peak period when the price of electricity is the highest.
- In all cases there is a negative NPV over a 10 year period for a battery purchased on 1 January 2017, and the payback and discounted payback periods are longer than 10 years.
- The economics of purchasing a battery system are likely to improve when the costs of a battery system reduce.

The total savings in Scenario 2 are smaller relative to those in Scenario 1, because most of the PV electricity is consumed at the time of generation. Irrespective of how much of the stored PV electricity is consumed during the Peak period, the payback and discounted payback periods are either close to 40 years or longer than 40 years when purchased on 1 January 2017.

Table A.3 Results for Scenario 2

Peak period consumption of the stored PV electricity (%)	Savings per kWh (cents per kWh)	Total savings ($ per annum)	Payback period (years)	Discounted payback period (years)	NPV ($)
Customer 1 - purchased 7 kWh battery on 1 January 2017					
25%	26.76	179	> 40	> 40	-9,300
50%	34.25	229	> 40	> 40	-8,849
75%	41.75	279	39	> 40	-8,398
Customer 1 - purchased 7 kWh battery on 1 January 2019					
25%	26.76	179	37	>40	-4,936
50%	34.25	229	29	>40	-4,485
75%	41.75	279	23	32	-4,034
Customer 2 - purchased 10 kWh battery on 1 January 2017					
25%	26.76	324	>40	>40	-10,717
50%	34.25	415	33	>40	-9,899
75%	41.75	506	27	39	-9,081
Customer 2 - purchased 10 kWh battery on 1 January 2019					
25%	26.76	324	25	35	-5,262
50%	34.25	415	20	25	-4,445
75%	41.75	506	16	20	-3,627

Note: The 10-year NPVs are calculated as of the date when the battery is purchased. The remaining stored PV electricity is assumed to be used in the Shoulder period.

Source: IPART analysis.

B Battery storage products available in the Australian market

Table B.1A sample range of battery storage products available in the Australian market as of November 2016

Battery brands	Battery power	Usable storage capacity	Asset life – No. of cycles at % Depth Of Discharge (DOD)	Price	Cost per total warranted kWh (1 cycle per day)
SimpliPhi Smart-Tech battery	- 3.1 kW steady - 4.1 kW peak	2.75 kWh	10,000 cycles at 80% DoD	$5,150 excluding installation	$0.51 (+ inverter cost)
BYD Mini ES	- 3 kW on grid - 2 kW off grid	3 kWh	6000 cycles at 80% DoD	$8,400 (fully installed)	$1.53
LG Chem RESU 6.5	- 4.2 kW steady - 4.6 kW peak (for 3 seconds)	5.9 kWh	3,200 cycles at 90% DoD	$6,600 excluding installation	$0.40 (+ inverter cost)
Tesla Powerwall	- 3.3 kW steady	6.4 kWh	740 cycles at 85%, then 1,087 at 72%, then 2,368 cycles at 60% DOD	$8,000 without an inverter	Approx. $0.50 (+ inverter cost)
Samsung ESS AIO	4 kW	6.48kWh	6,000 cycles at 90% DoD	$12,000 excluding installation	$1.01
Sunverge SIS	- 5 kW steady - 8.5kW peak	9.86 kWh	8,000 cycles at 85% DOD	$26,000 (fully installed, including a hybrid inverter)	$0.72
ZEN Freedom Powerbank	5 kW	14.4 kWh	6,000 cycles at 90% DoD	$21,750 (fully installed)	$0.83

[a] http://reneweconomy.com.au/2015/lg-chem-pushes-australian-battery-storage-prices-further-down-the-curve-40369 accessed 25 October 2016.

Note: Hybrid inverter is an inverter that converts both PV panels' and the batteries' DC power to AC power, and takes care of the required battery control and switching functions.

Source: https://www.solarquotes.com.au/battery-storage/comparison-table/ accessed 21 November 2016.

Table B.1 compares the retail prices of several battery storage products available on the Australian market. We have presented a sample of battery models of varying storage capacity, power and efficiency levels. When shopping for your best value option in battery storage you should look at the following factors:

Usable storage capacity (kWh)

This is the amount of electricity stored in a battery that can be used to power a household. When considering the size of battery to purchase, you should first conduct an energy usage audit to determine your household energy requirement. An accredited solar battery system installer should be able to assist with customised software to monitor household energy usage. This can indicate the optimum number of batteries and solar panels needed and give an approximate payback period.

Battery life and depth of discharge (DoD)

Battery life is typically expressed as a function of cycle life at a given depth of discharge (DoD). Completely draining a battery daily can shorten its life. A battery discharging at 100% DoD may lose up to 30% of its initial capacity after 500 cycles, which equates to about two years of daily use. But at 80% DoD, the battery could last up to 1900 cycles (about five years) before losing a significant amount of its capacity.[9]

Cost per warranted kWh

This benchmark compares the relative cost effectiveness of battery systems. It is calculated by dividing the retail price of the battery with 'Warranted kWh (1 cycle per day)' over the expected asset life of a battery system. We have assumed residential households with larger batteries are likely to discharge approximately once per day.

Installation and hybrid solar inverter

It is important to clarify whether the retail price includes installation and a hybrid solar inverter, which may add to the cost of a battery system. Most solar-battery systems require a ‘hybrid’ solar inverter which has a higher level of control functionality than traditional inverters for solar PV.[10] Hybrid inverters in

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[9] Depth of Discharge (DoD) describes how deeply the battery is discharged. If a battery has delivered 30% of its energy, and 70% energy reserved, then DoD of this battery is 30%. If a battery is fully discharged, the DoD of this battery is 100%. For example, 6,000 cycles at 90% DoD means the battery should be able to discharge 90% of its capacity then recharge 6,000 times before it reaches the end of its life. http://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/10057/Teslas-Powerwall-by-the-Numbers.aspx

[10] A battery inverter is essential for several functions: it regulates the electricity flow between the battery and the grid, it monitors and controls the rate of charge and discharge to ensure household is utilising on-site solar generation and it controls the rate of charge and discharge to prolong battery life.

the Australian market currently start at around $1.00 per watt (non-installed) this equates to around $5,000 for a 5kW hybrid inverter.